# 证　明

## CERTIFICATE

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| | |
|---|---|
| **国 际 申 请 号:**<br>**INTERNATIONAL APPLICATION NUMBER** | **PCT/CN03/00340** |
| **国 际 申 请 日:**<br>**INTERNATILNAL FILING DATE** | **12 MAY 2003(12.05.03)** |
| **发 明 名 称 :**<br>TITLE OF INVENTION | METHOD AND MECHANISM OF PZT<br>MICRO-ACTUATOR ATTACHMENT FOR THE HARD |
| **申 请 人:**<br>**APPLICANT** | **SAE MAGNETICE(H.K.)LTD** |

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王景川

二零零三年六月四日

JUNE 04, 2003

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# PCT

## REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

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International Application No. PCT/CN 03/00340

International Filing Date 12 MAY 2003 (12.05.03)

RO/CN 中华人民共和国国家知识产权局 PCT International Application

Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference *(if desired) (12 characters maximum)* FPEL03150014

**Box No. I TITLE OF INVENTION**

METHOD AND MECHANISM OF PZT MICRO-ACTUATOR ATTACHMENT FOR THE HARD DISK DRIVER ARM

**Box No. II APPLICANT** ☐ This person is also inventor

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

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This person is:
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☐ applicant and inventor
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☒ Further applicants and/or (further) inventors are indicated on a continuation sheet.

**Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE**

The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as: ☒ agent ☐ common representative

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**Continuation of Box No. III** **FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)**

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- ☐ applicant and inventor
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This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

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- ☐ applicant and inventor
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Applicant's registration No. with the Office

State *(that is, country)* of nationality:

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Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

This person is:
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- ☐ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

Applicant's registration No. with the Office

State *(that is, country)* of nationality:

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Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

This person is:
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- ☐ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

Applicant's registration No. with the Office

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This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

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☐ EP **European Patent:** AT Austria, BE Belgium, BG Bulgaria, CH & LI Switzerland and Liechtenstein, CY Cyprus, CZ Czech Republic, DE Germany, DK Denmark, EE Estonia, ES Spain, FI Finland, FR France, GB United Kingdom, GR Greece, IE Ireland, IT Italy, LU Luxembourg, MC Monaco, NL Netherlands, PT Portugal, SE Sweden, SK Slovakia, TR Turkey, and any other State which is a Contracting State of the European Patent Convention and of the PCT

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The priority of the following earlier application(s) is hereby claimed:

| Filing date of earlier application *(day/month/year)* | Number of earlier application | Where earlier application is: | | |
|---|---|---|---|---|
| | | national application: country or Member of WTO | regional application:* regional Office | international application: receiving Office |
| item (1) | | | | |
| item (2) | | | | |
| item (3) | | | | |
| item (4) | | | | |
| item (5) | | | | |

☐ Further priority claims are indicated in the Supplemental Box.

The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) *(only if the earlier application was filed with the Office which for the purposes of this international application is the receiving Office)* identified above as:

☐ all items ☐ item (1) ☐ item (2) ☐ item (3) ☐ item (4) ☐ item (5) ☐ other, see Supplemental Box

** Where the earlier application is an ARIPO application, indicate at least one country party to the Paris Convention for the Protection of Industrial Property or one Member of the World Trade Organization for which that earlier application was filed (Rule 4.10(b)(ii)):* ....

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**Choice of International Searching Authority (ISA)** *(if two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used)*:

ISA / CN

**Request to use results of earlier search; reference to that search** *(if an earlier search has been carried out by or requested from the International Searching Authority)*:

Date *(day/month/year)* Number Country *(or regional Office)*

**Box No. VIII DECLARATIONS**

The following **declarations** are contained in Boxes Nos. VIII (i) to (v) *(mark the applicable check-boxes below and indicate in the right column the number of each type of declaration)*: Number of declarations

| | | |
|---|---|---|
| ☐ Box No. VIII (i) | Declaration as to the identity of the inventor | : |
| ☐ Box No. VIII (ii) | Declaration as to the applicant's entitlement, as at the international filing date, to apply for and be granted a patent | : |
| ☐ Box No. VIII (iii) | Declaration as to the applicant's entitlement, as at the international filing date, to claim the priority of the earlier application | : |
| ☐ Box No. VIII (iv) | Declaration of inventorship (only for the purposes of the designation of the United States of America) | : |
| ☐ Box No. VIII (v) | Declaration as to non-prejudicial disclosures or exceptions to lack of novelty | : |

**Box No. IX CHECK LIST; LANGUAGE OF FILING**

This international application **contains**:

(a) the following number of **sheets in paper form**:

| | | |
|---|---|---|
| request (including declaration sheets) | : | 5 |
| description (excluding sequence listing part) | : | 8 |
| claims | : | 6 |
| abstract | : | 1 |
| drawings | : | 9 |
| **Sub-total number of sheets** | : | 29 |
| sequence listing part of description *(actual number of sheets if filed in paper form, whether or not also filed in computer readable form; see (b) below)* | : | |
| **Total number of sheets** | : | 29 |

(b) sequence listing part of description filed in **computer readable form**

(i) ☐ only (under Section 801(a)(i))

(ii) ☐ in addition to being filed in paper form (under Section 801(a)(ii))

**Type and number of carriers** (diskette, CD-ROM, CD-R or other) on which the sequence listing part is contained *(additional copies to be indicated under item 9(ii), in right column)*: .....

This international application is **accompanied by** the following item(s) *(mark the applicable check-boxes below and indicate in right column the number of each item)*:

| | | Number of items |
|---|---|---|
| 1. ☒ fee calculation sheet | : | 1 |
| 2. ☒ original separate power of attorney | : | 1 |
| 3. ☐ original general power of attorney | : | |
| 4. ☐ copy of general power of attorney; reference number, if any: ..... | : | |
| 5. ☐ statement explaining lack of signature | : | |
| 6. ☐ priority document(s) identified in Box No. VI as item(s): ..... | : | |
| 7. ☐ translation of international application into *(language)*: ..... | : | |
| 8. ☐ separate indications concerning deposited microorganism or other biological material | : | |
| 9. ☐ sequence listing in computer readable form (indicate also type and number of carriers (diskette, CD-ROM, CD-R or other )) | | |
| (i) ☐ copy submitted for the purposes of international search under Rule 13*ter* only (and not as part of the international application) | : | |
| (ii) ☐ *(only where check-box (b)(i) or (b)(ii) is marked in left column)* additional copies including, where applicable, the copy for the purposes of international search under Rule 13*ter* | : | |
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| 10. ☐ other *(specify)*: ..... | : | |

**Figure of the drawings** which should accompany the abstract: FIG. 6

**Language of filing** of the international application: EN

**Box No. X SIGNATURE OF APPLICANT, AGENT OR COMMON REPRESENTATIVE**

*Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).*

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|---|---|---|
| 1. Date of actual receipt of the purported international application: 12 MAY 2003 (12.05.03) | | 2. Drawings: ☐ received: |
| 3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application: | | |
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# PCT

**FEE CALCULATION SHEET**
**Annex to the Request**

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International Application No. PCT/CN 03/00340

Date stamp of the receiving Office 12 MAY 2003 (12.05.03)

Applicant's or agent's file reference FPEL03150014

Applicant
SAE MAGNETICS (H.K.) LTD.

**CALCULATION OF PRESCRIBED FEES**

1. TRANSMITTAL FEE . . . . . CNY500 [T] — CNY 500.-
2. SEARCH FEE . . . . . CNY1500 [S] — CNY 1500.-
   International search to be carried out by _____
   *(If two or more International Searching Authorities are competent to carry out the international search, indicate the name of the Authority which is chosen to carry out the international search.)*
3. INTERNATIONAL FEE
   **Basic Fee**
   Where item (b) of Box No. IX applies, enter **Sub-total number of sheets** } 29
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   [b1] first 30 sheets . . . . . CHF650 [b1] — CHF 650.-
   [b2] _____ (number of sheets in excess of 30) x _____ (fee per sheet) = _____ [b2]
   [b3] additional component (only if sequence listing part of description is filed in computer readable form under Section 801(a)(i), or both in that form and on paper, under Section 801(a)(ii)):
   400 x _____ (fee per sheet) = _____ [b3]
   Add amounts entered at b1, b2 and b3 and enter total at B . . . . CHF650 [B] — CHF 650.-

   **Designation Fees**
   The international application contains 1 designations.
   1 (number of designation fees payable *(maximum 5)*) x CHF140 (amount of designation fee) = CHF140 [D] — CHF 140.-
   Add amounts entered at B and D and enter total at I . . . . . CHF790 [I] — CHF 790.-
   *(Applicants from certain States are entitled to a reduction of 75% of the international fee. Where the applicant is (or all applicants are) so entitled, the total to be entered at I is 25% of the sum of the amounts entered at B and D.)*
4. FEE FOR PRIORITY DOCUMENT *(if applicable)* . . . . . [P] — CNY 2000.-
5. TOTAL FEES PAYABLE . . . . . CNY2000CHF790 TOTAL — CHF 790.-
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☐ The designation fees are not paid at this time.

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☐ cheque ☐ bank draft ☐ revenue stamps ☐ other *(specify)*:

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Receiving Office: RO/
Deposit Account No.
Date: 05/03/2003
Name:
Signature:

☒ Authorization to charge the total fees indicated above.
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*See Notes to the fee calculation sheet*

# Method and Mechanism of PZT Micro-Actuator Attachment for the Hard Disk Driver Arm

## Background Information

**[0001]** The present invention relates to magnetic hard disk drives. More specifically, the present invention relates to a method of assembling micro-actuators.

**[0002]** In the art today, different methods are utilized to improve recording density of hard disk drives. **Figure 1** provides an illustration of a typical disk drive. The typical disk drive has a head gimbal assembly (HGA) configured to read from and write to a magnetic hard disk 101. The HGA and the magnetic hard disk 101 are mounted to the base 102 of a main board 103. The disk 101 is rotated relative to the base 102 by a spindle motor 104. The HGA typically includes an actuator arm 105 and a load beam 106. The HGA supports and positions a magnetic read/write slider 107 above the magnetic hard disk 101. The HGA is rotated relative to the base 102 along the axis of a bearing assembly 108 by a voice coil motor 109. A relay flexible printed circuit 110 connects a board unit 111 to the magnetic read/write slider 107.

**[0003]** **Figures 2a-d** provide an illustration of two embodiments of a piezoelectric micro-actuator. **Figure 2a** illustrates a micro-actuator with a U-shaped ceramic frame configuration 201. The frame 201 may be Zirconia. The frame 201 may have two arms 202 opposite a base 203. A slider 204 may be held by the two arms 202 at the end opposite the base 203. A strip of piezoelectric material 205 may be attached to each arm 202. **Figure 2b** illustrates the micro-actuator as attached to an actuator suspension 206. The micro-actuator may be coupled to a suspension tongue 207. Traces 208, coupled along the suspension 206, apply a voltage to the strips of piezoelectric material 205. These voltages may cause the strips 205 to contract and expand, moving the placement of the slider 204.

**[0004]** **Figure 2c** illustrates an alternate version of the micro-actuator. In this embodiment, a metallic frame 209 has a base 210 with two arms 211 perpendicular to

the plane of the base 210. A slider support 212 may hold the slider between the two arms 211. A strip of piezoelectric material 213 is coupled to each arm 211. The micro-actuator may then be attached to the head suspension 206 in the same manner as the ceramic micro-actuator, as shown in **Figure 2d**.

**[0005]** One embodiment of a method of manufacturing the metallic frame 209 is shown in **Figures 3a-d**. The frame 209 may be stainless steel, such as SUS304. As shown in **Figure 3a,** the two arms 211 of the metallic frame 209 may be formed using vertical forming by machine or laser. A hole 301 may be formed on the slider support 212 to facilitate the slider 204 mounting. The support connections 302 and the base connections 303 may be narrowed to improve resonance. The two strips of piezoelectric material 213 may each have at least one contact pad 304 attached that allows the strips 213 to be electrically coupled to a control circuit. As shown in **Figure 3b**, the strips 213 may be coupled to the arms 211 of the metallic frame 209. As shown in **Figure 3c**, the slider 204 may be coupled to the slider support 212. The slider 204 may be coupled using epoxy or some other kind of adhesive. The epoxy may be cured using the hole 301 in the slider support 212. As shown in **Figure 3d**, the micro-actuator may then be attached to the suspension tongue 207.

**[0006]** **Figures 4a-b** provides an illustration in a pair of charts of the effect of adhesive thickness on stroke and resonance. **Figure 4a** compares the stroke in micrometers to the adhesive thickness in millimeters. In this example, stroke pertains to the amount of deflection of the slider caused by the micro-actuator. **Figure 4b** compares the resonance frequency of the micro-actuator in kilohertz to the adhesive thickness in millimeters. Due to the small size of the micro-actuators and the fragile nature of the piezoelectric material, stress fractures and distortions remain problems.

Brief Description Of The Drawings

[0007] **Figure 1** provides an illustration of a typical disk drive.

[0008] **Figures 2a-d** provide an illustration of two embodiments of a piezoelectric micro-actuator.

[0009] **Figures 3a-d** provide an illustration of one embodiment of a method of manufacturing the metallic frame.

[0010] **Figures 4a-b** provide an illustration in a pair of charts of the effect of adhesive thickness on stroke and resonance.

[0011] **Figures 5a-e** provide an illustration of one embodiment of a method for attaching the strips of piezoelectric material to the metallic frame.

[0012] **Figure 6** provides an illustration in a flowchart of one embodiment of a method for using the fixture

[0013] **Figures 7a-e** provide an illustration of an alternate embodiment of a method for attaching the strips of piezoelectric material to multiple metallic frames.

[0014] **Figures 8a-f** provide an illustration of an alternate embodiment of a method for attaching the strips of piezoelectric material to the metallic frame.

[0015] **Figures 9a-e** provide an illustration of an alternate embodiment of a method for attaching the strips of piezoelectric material to the metallic frame.

Detailed Description

**[0016]** A fixture with a shaped molding may hold a first micro-actuator part and a second micro-actuator part in place for coupling while maintaining the structure of the first micro-actuator part. The first micro-actuator part and the second micro-actuator part may be a frame or a strip of piezoelectric material. A vacuum nozzle system embedded in the fixture may hold the first micro-actuator part in place. A mobile vacuum nozzle system may hold the second micro-actuator in place and positions the second micro-actuator part relative to the first micro-actuator part. A camera system may monitor the process. A dispenser may apply epoxy between the first and second micro-actuator part. An ultraviolet source may provide ultraviolet radiation for curing.

**[0017]** **Figures 5a-e** illustrate one embodiment of a method for attaching the strips of piezoelectric material 213 to the metallic frame 209. As shown in **Figure 5a**, the metallic frame 209 may be placed on a fixture 501 to maintain the structure of the metallic frame 209 while the strips of piezoelectric material 213 are added. The fixture 501 may have a shaped indentation 502 to match the exterior of the metallic frame 209. Alternately, the fixture 501 may have a shaped protrusion that matches the interior of the metallic frame 209. A vacuum nozzle 503 embedded within the fixture 501 may hold the metallic frame 209 in place on the fixture 501. The base 210 may be placed on the vacuum nozzle 503. As shown in **Figure 5b**, a strip of piezoelectric material 213 may be held aloft by a mobile vacuum nozzle 504. The mobile vacuum nozzle 504 may be moved in all three dimensions and is rotatable along the axis of the nozzle 504. A camera system 505 may be used to monitor the placement of the strip of piezoelectric material 213. A dispenser places adhesive on the metallic frame 209. In one embodiment, the adhesive is epoxy. As shown in **Figure 5c**, the mobile vacuum nozzle 504 may place the strip of piezoelectric material 213 against the metallic frame 209. An ultraviolet source 506 may be used to cure the epoxy bond between the strip of piezoelectric material 213 and the metallic frame 209. After a time delay of 3-9 seconds, the ultraviolet source 506 is

turned off and the mobile vacuum nozzle 504 is removed. In an alternate embodiment, the mobile vacuum nozzle 504 is removed and the ultraviolet source 506 is turned off. In an alternative embodiment illustrated in **Figure 5d**, the fixture 501 may maintain the structure of multiple metallic frames 209. The mobile vacuum nozzle 504 may place the strip of piezoelectric material 213 against the arm 211 of the first metallic frame 209. As shown in **Figure 5e**, the ultraviolet source 506 may then cure the epoxy bond before moving to the next metallic frame 209.

**[0018]** One embodiment of a method for using the fixture of **Figures 5d-e** is illustrated in the flowchart of **Figure 6**. To start (Block 605), the frame 209 may be laminated (Block 610). The frame 209 may be placed upon the fixture 501 (Block 615). The strip of piezoelectric material 213 may be picked up by the mobile vacuum nozzle 504 (Block 620). The location of the strip of piezoelectric material 213 may be confirmed and then adjustments are made as necessary (Block 625). Epoxy may be added to the frame 209 (Block 630). The strip of piezoelectric material 213 may be attached to the frame 209 (Block 635). The epoxy is cured by ultraviolet radiation (Block 640). A camera system 505 may confirm if further frames 209 are on the fixture 501 (Block 645). If further frames 209 are not on the fixture 501, the fixture 501 is exchanged (Block 650). Otherwise, the next frame is worked on (Block 610).

**[0019]** **Figures 7a-e** illustrate an alternate embodiment of a method for attaching the strips of piezoelectric material 213 to multiple metallic frames 209. As shown in **Figure 7a**, a first metallic frame 209 is placed on a first fixture 701 and a second metallic frame 209 is placed on the second fixture 702 to maintain the structure of the metallic frames 209 while the strips of piezoelectric material 213 are added. The first fixture 701 and the second fixture 702 may have shaped indentations 703 to match the exterior of the metallic frame 209. Alternately, the first fixture 701 and the second fixture 702 may have a shaped protrusion that matches the interior of the metallic frame 209. A first vacuum nozzle 704 embedded within the first fixture 701 may hold a metallic frame 209 in place on the first fixture 701 and a second

vacuum nozzle 705 embedded within the first fixture 702 may hold a metallic frame 209 in place on the second fixture 702. As shown in **Figure 7b**, two strips of piezoelectric material 213 may be held aloft by a mobile dual vacuum nozzle 706. The mobile dual vacuum nozzle 706 may be moved in all three dimensions. A camera system 505 may be used to monitor the placement of the strip of piezoelectric material 213. A dispenser places adhesive on the metallic frame 209. In one embodiment, the adhesive is epoxy. As shown in **Figure 7c**, the mobile dual vacuum nozzle 706 may place the strips of piezoelectric material 213 against the metallic frames 209. A first ultraviolet source 707 and a second ultraviolet source 708 may be used to cure the epoxy bonds between the strips of piezoelectric material 213 and the metallic frames 209. After a time delay of 3-9 seconds, the mobile dual vacuum nozzle 706 is removed and the first ultraviolet source 707 and the second ultraviolet source 708 are turned off. In an alternative embodiment illustrated in **Figure 7d**, the first fixture 701 and the second fixture 702 may each maintain the structure of multiple metallic frames 209. The mobile dual vacuum nozzle 706 may place the strip of piezoelectric material 213 against the arm 211 of a first and second metallic frame 209. As shown in **Figure 7e**, the first ultraviolet source 707 and the second ultraviolet source 708 may then cure the epoxy bond before moving to the next two metallic frames 209.

**[0020]** **Figures 8a-f** illustrate an alternate embodiment of a method for attaching the strips of piezoelectric material 213 to the metallic frame 209. As shown in **Figure 8a**, the two strips of piezoelectric material 213 may be placed on the fixture 801. The fixture 801 may have a shaped indentation 802 to match the exterior of the metallic frame 209 and the two strips of piezoelectric material 213. A vacuum nozzle system 803 embedded within the fixture 501 may hold the two strips of piezoelectric material 213 in place on the fixture 801. As shown in **Figure 8b**, a frame 209 may be held aloft by a mobile vacuum nozzle 804, with the arms oriented downward. The mobile vacuum nozzle 804 may be moved in all three dimensions and is rotatable along the axis of the nozzle 804. A camera system 805 may be used

to monitor the placement of the frame 209. As shown in **Figure 8c,** a first dispenser 806 and a second dispenser 807 may place adhesive on the metallic frame 209. In one embodiment, the adhesive is epoxy. As shown in **Figure 8d**, the mobile vacuum nozzle 804 may move about to spread the epoxy evenly on the frame 209. As shown in **Figure 8e**, the mobile vacuum nozzle 804 may place the metallic frame 209 against the strip of piezoelectric material 213. As shown in **Figure 8f,** a first ultraviolet source 808 and a second ultraviolet source 809 may be used to cure the epoxy bond between the strip of piezoelectric material 213 and the metallic frame 209. After a time delay of 3-9 seconds, the mobile vacuum nozzle 804 may be removed after the first ultraviolet source 808 and the second ultraviolet source 809 are turned off. In an alternate embodiment, the mobile vacuum nozzle 804 may be removed before the first ultraviolet source 808 and the second ultraviolet source 809 are turned off.

**[0021]** **Figures 9a-e** illustrate an alternate embodiment of a method for attaching the strips of piezoelectric material 213 to the metallic frame 209. As shown in **Figure 9a**, the two strips of piezoelectric material 213 may be placed on the fixture 801. The fixture 801 may have a shaped indentation 802 to match the exterior of the metallic frame 209 and the two strips of piezoelectric material 213. A vacuum nozzle system 803 embedded within the fixture 501 may hold the two strips of piezoelectric material 213 in place on the fixture 801. A frame 209 may be held aloft by a mobile vacuum nozzle 804, with the arms oriented upward. The mobile vacuum nozzle 804 may be moved in all three dimensions and is rotatable along the axis of the nozzle 804. A camera system 805 may be used to monitor the placement of the frame 209. As shown in **Figure 9b,** a first dispenser 806 and a second dispenser 807 may place adhesive on the metallic frame 209. In one embodiment, the adhesive is epoxy. As shown in **Figure 9c**, the mobile vacuum nozzle 804 may move about to spread the epoxy evenly on the frame 209. As shown in **Figure 9d**, the mobile vacuum nozzle 804 may place the metallic frame 209 against the strip of piezoelectric material 213. As shown in **Figure 9e,** a first ultraviolet source 808

and a second ultraviolet source 809 may be used to cure the epoxy bond between the strip of piezoelectric material 213 and the metallic frame 209. After a time delay of 3-9 seconds, the mobile vacuum nozzle 804 may be removed after the first ultraviolet source 808 and the second ultraviolet source may be turned off. In an alternate embodiment, the mobile vacuum nozzle 804 may be removed before the first ultraviolet source 808 and the second ultraviolet source 809 are turned off.

**[0022]** Although several embodiments are specifically illustrated and described herein, it will be appreciated that modifications and variations of the present invention are covered by the above teachings and within the purview of the appended claims without departing from the spirit and intended scope of the invention.

What is claimed is

1. A method, comprising:

placing a first micro-actuator part in a molding of a fixture;

coupling a second micro-actuator part to the first micro-actuator part; and

using the fixture to maintain a structure of the first micro-actuator part and the second micro-actuator part.

2. The method of claim 1, further comprising holding the first micro-actuator part in place with an embedded vacuum nozzle system.

3. The method of claim 1, further comprising positioning the second micro-actuator part relative to the first micro-actuator part for coupling using a first mobile vacuum nozzle system

4. The method of claim 1, wherein the first micro-actuator part is a micro-actuator frame.

5. The method of claim 4, wherein the micro-actuator frame is metal.

6. The method of claim 4, wherein the molding is a shaped protrusion that matches the interior of the first micro-actuator frame.

7. The method of claim 4, wherein the second micro-actuator part is a first strip of piezoelectric material.

8. The method of claim 7, further comprising positioning a second strip of piezoelectric material with a second mobile vacuum nozzle system.

9. The method of claim 7, further comprising holding a second strip of piezoelectric material with the first mobile vacuum nozzle system.

10. The method of claim 1, wherein the molding is a shaped indentation that matches the exterior of the first micro-actuator part, the second micro-actuator part, and a third micro-actuator part.

11. The method of claim 10, wherein the first micro-actuator part is a first strip of piezoelectric material and the third micro-actuator part is a second strip of piezoelectric material.

12. he method of claim 10, wherein the second micro-actuator part is a micro-actuator frame.

13. The method of claim 12, wherein the micro-actuator frame is metal.

14. The method of claim 1, further comprising maintaining the structure of multiple frames simultaneously with multiple moldings.

15. The method of claim 1, further comprising observing the fixture with a camera system.

16. The method of claim 1, further comprising applying an adhesive between the first micro-actuator part and the second micro-actuator part.

17. The method of claim 16, further comprising curing the adhesive is cured with ultraviolet radiation.

18. A fixture, comprising:

a molding to hold a first micro-actuator part to be coupled to a second micro-actuator part and shaped to maintain a structure of the first micro-actuator part and the second micro-actuator part.

19. The fixture of claim 18, further comprising an embedded vacuum nozzle system to hold the first micro-actuator part in place.

20. The fixture of claim 18, wherein a first mobile vacuum nozzle system positions the second micro-actuator part relative to the first micro-actuator part for coupling.

21. The fixture of claim 18, wherein the first micro-actuator part is a micro-actuator frame.

22. The fixture of claim 21, wherein the micro-actuator frame is metal.

23. The fixture of claim 21, wherein the molding is a shaped protrusion that matches the interior of the micro-actuator frame.

24. The fixture of claim 21, wherein the second micro-actuator part is a first strip of piezoelectric material.

25. The fixture of claim 24, wherein a second strip of piezoelectric material is positioned with a second mobile vacuum nozzle system.

26. The fixture of claim 24, wherein the first mobile vacuum nozzle system holds a second strip of piezoelectric material .

27. The fixture of claim 18, wherein the molding is a shaped indentation that

matches the exterior of the first micro-actuator part, the second micro-actuator part, and a third micro-actuator part.

28. The fixture of claim 27, wherein the first micro-actuator part is a first strip of piezoelectric material and the third micro-actuator part is a second strip of piezoelectric material.

29. The fixture of claim 27, wherein the second micro-actuator part is a micro-actuator frame

30. The fixture of claim 29, wherein the micro-actuator frame is metal.

31. The fixture of claim 18, further comprising multiple moldings capable of maintaining the structure of multiple frames simultaneously.

32. The fixture of claim 18, wherein a camera system observes the fixture.

33. The fixture of claim 18, wherein an adhesive applicator applies an adhesive between the first micro-actuator part and the second micro-actuator part.

34. The fixture of claim 33, wherein the adhesive is cured with ultraviolet radiation.

35. A system, comprising:

an embedded vacuum nozzle system to hold a first micro-actuator part to be coupled to a second micro-actuator part;

a first mobile vacuum nozzle system positions the second micro-actuator part relative to the first micro-actuator part for coupling; and

a molding shaped to maintain a structure of the first micro-actuator part

36. The system of claim 35, wherein the molding is a shaped protrusion that matches the interior of the first micro-actuator part.

37. The system of claim 35, wherein the first micro-actuator part is a micro-actuator frame.

38. The system of claim 37, wherein the micro-actuator frame is metal.

39. The system of claim 37, wherein the second micro-actuator part is a first strip of piezoelectric material.

40. The system of claim 39, further comprising a second mobile vacuum nozzle system to position a second strip of piezoelectric material.

41. The system of claim 39, wherein the first mobile vacuum nozzle system holds a second strip of piezoelectric material.

42. The system of claim 35, wherein the molding is a shaped indentation that matches the exterior of the first micro-actuator part, the second micro-actuator part, and a third micro-actuator part.

43. The system of claim 42, wherein the first micro-actuator part is a first strip of piezoelectric material and the third micro-actuator part is a second strip of piezoelectric material.

44. The system of claim 43, wherein the second micro-actuator part is a micro-actuator frame.

45. The system of claim 44, wherein the micro-actuator frame is metal.

45. The system of claim 44, wherein the micro-actuator frame is metal.

46. The system of claim 35, further comprising multiple moldings capable of maintaining the structure of multiple frames simultaneously.

47. The system of claim 35, further comprising a camera system to observe the fixture.

48. The system of claim 35, further comprising an adhesive applicator to apply an adhesive between the first micro-actuator part and the second micro-actuator part.

49. The system of claim 48, wherein curing the adhesive is cured with ultraviolet radiation.

Abstract

A fixture with a shaped molding may hold a first micro-actuator part and a second micro-actuator part in place for coupling while maintaining the structure of the first micro-actuator part. The first micro-actuator part and the second micro-actuator part may be a frame or a strip of piezoelectric material. A vacuum nozzle system embedded in the fixture may hold the first micro-actuator part in place. A mobile vacuum nozzle system may hold the second micro-actuator in place and positions the second micro-actuator part relative to the first micro-actuator part. A camera system may monitor the process. A dispense may apply epoxy between the first and second micro-actuator part. An ultraviolet source may provide ultraviolet radiation for curing.

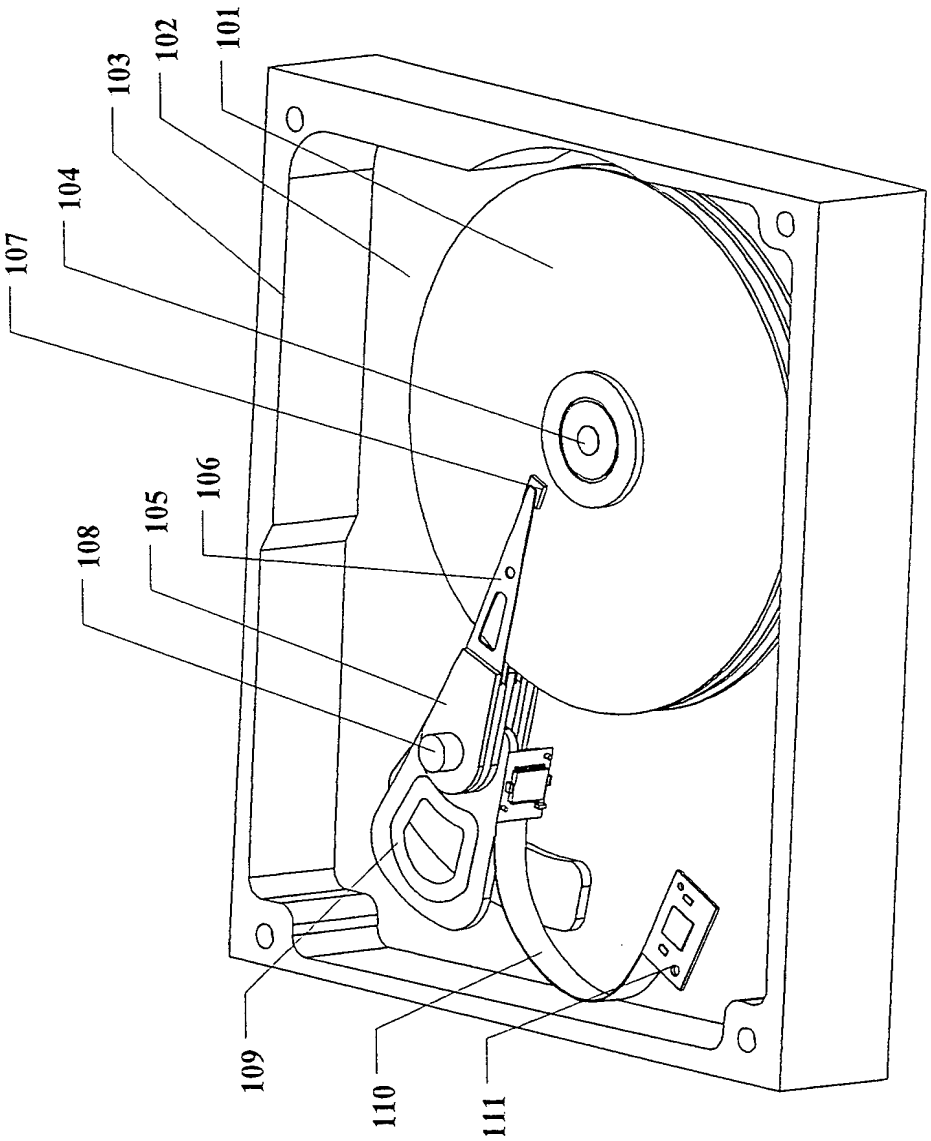


FIG. 1
(Prior Art)

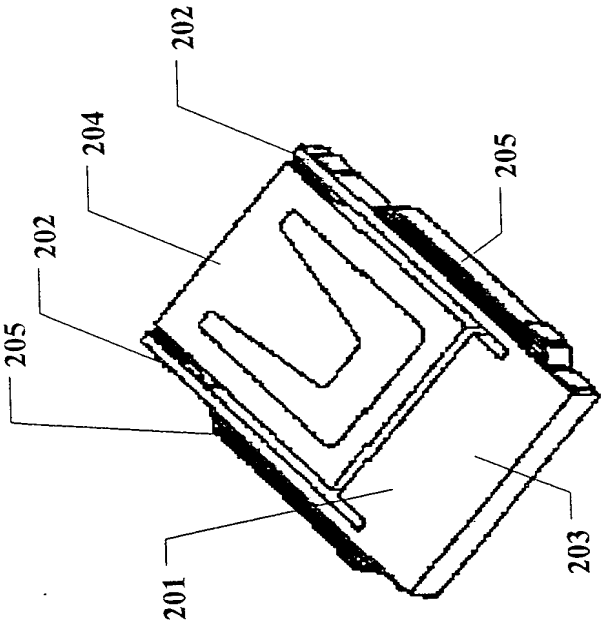


FIG. 2a

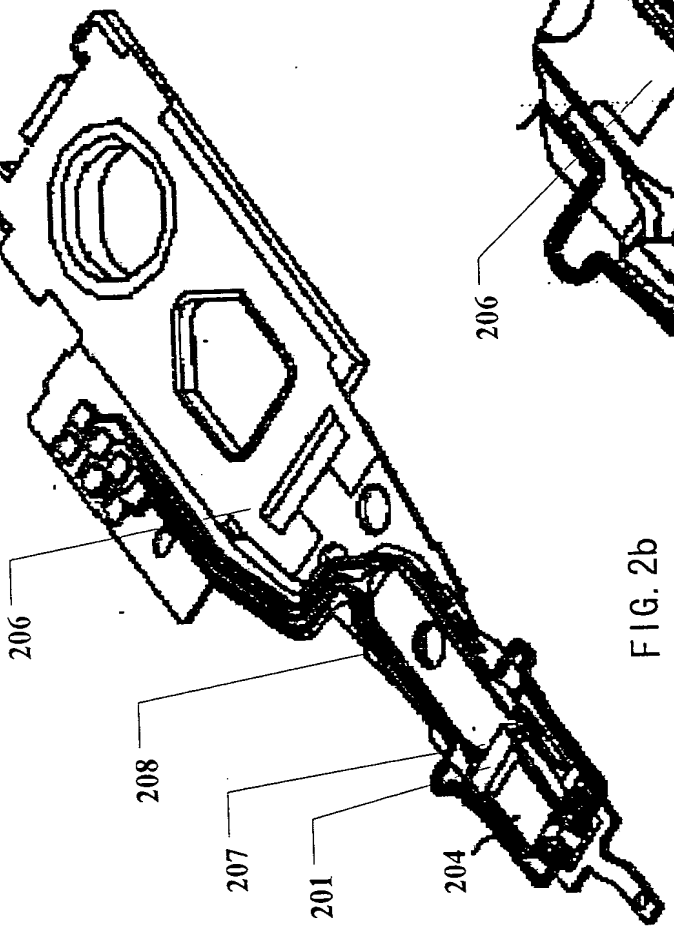


FIG. 2b

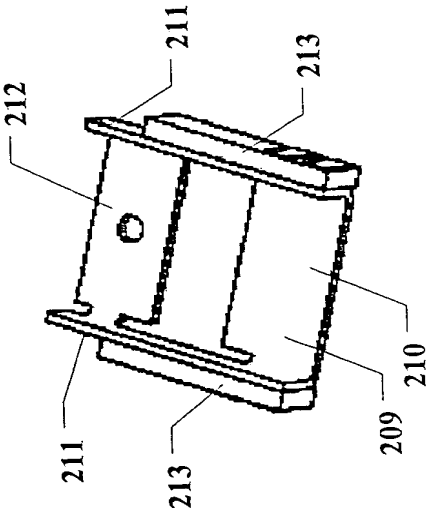


FIG. 2c

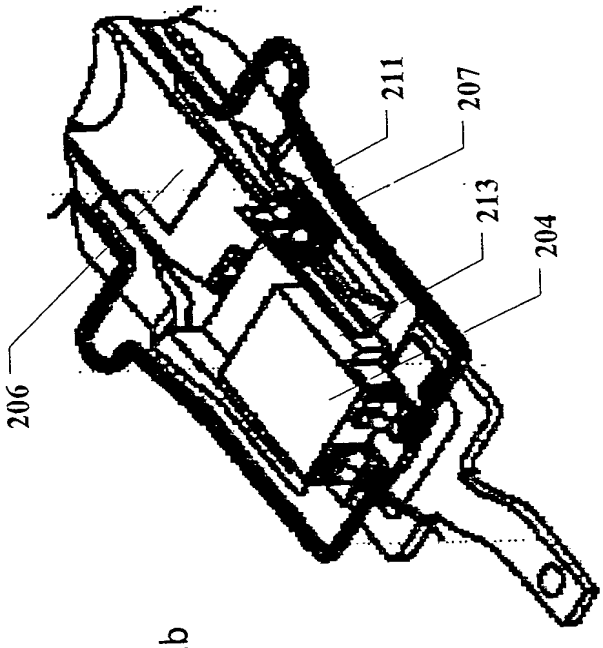


FIG. 2d

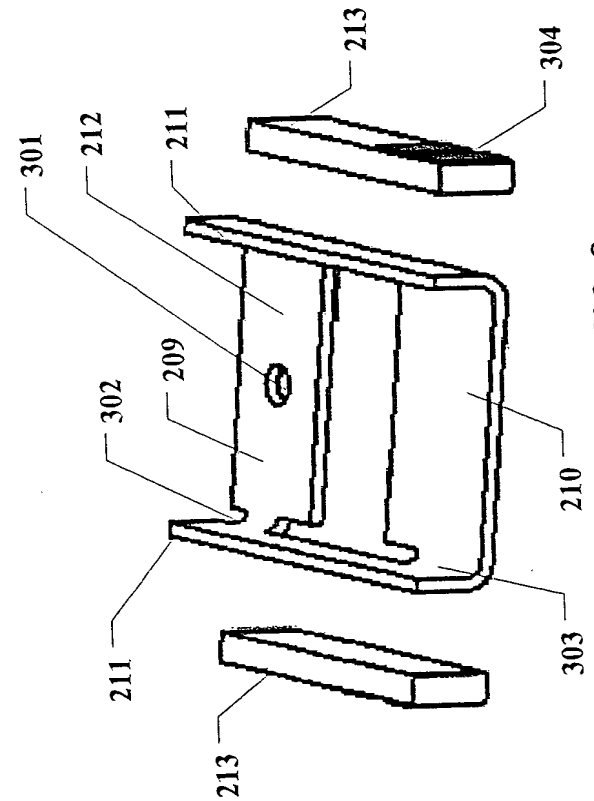


FIG. 3a

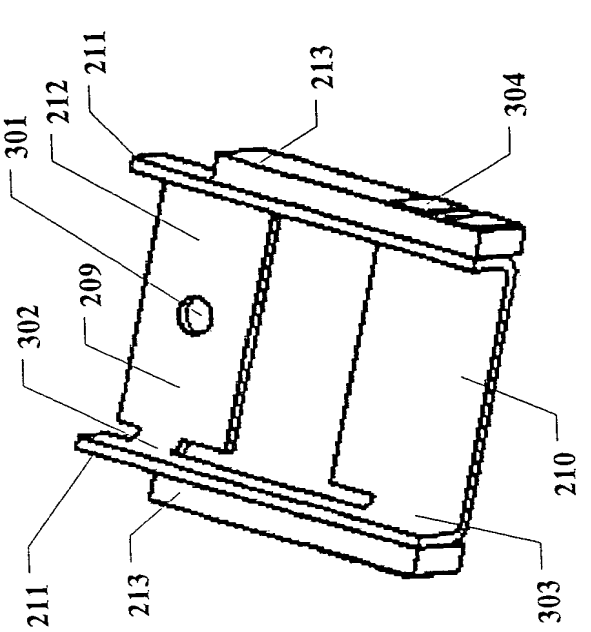


FIG. 3b

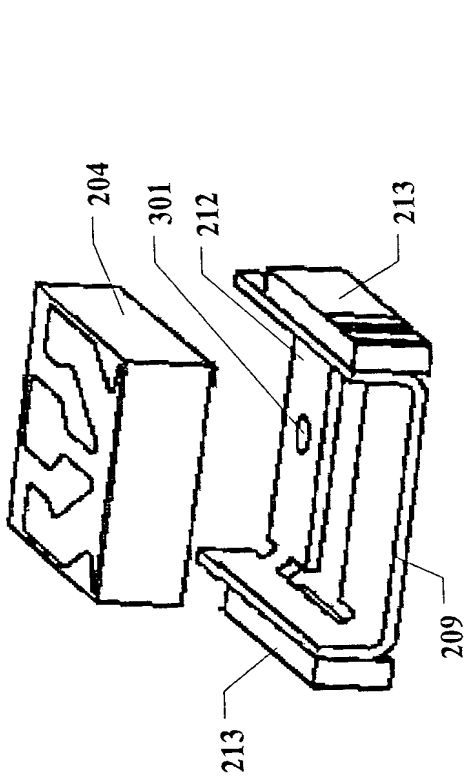


FIG. 3c

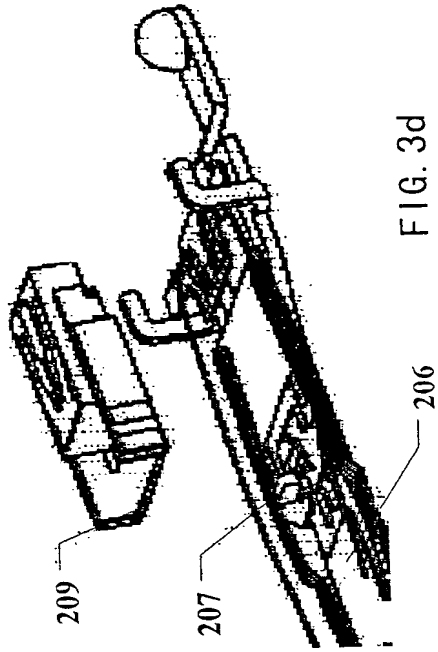


FIG. 3d

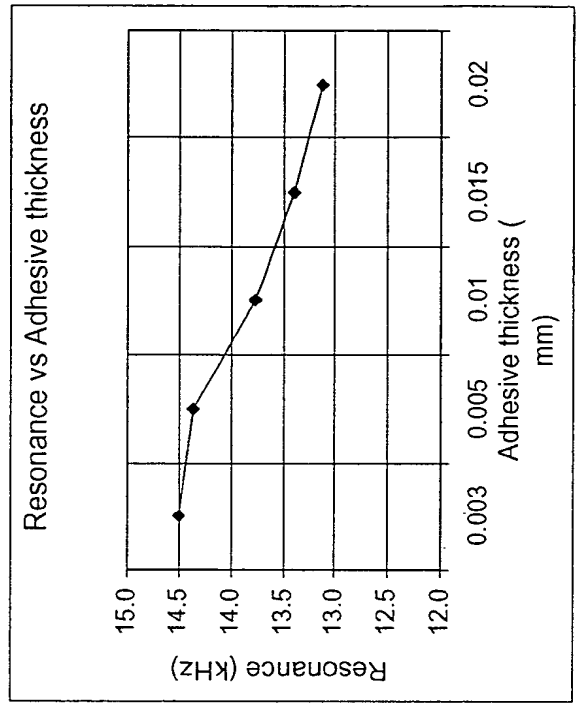
Resonance vs Adhesive thickness
Resonance (kHz)
15.0
14.5
14.0
13.5
13.0
12.5
12.0
0.003
0.005
0.01
0.015
0.02
Adhesive thickness ( mm)

FIG. 4b

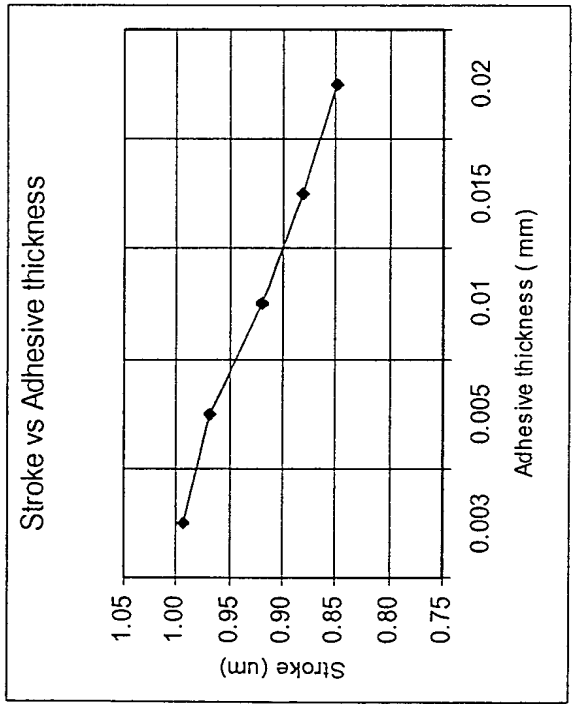
Stroke vs Adhesive thickness
Stroke (um)
1.05
1.00
0.95
0.90
0.85
0.80
0.75
0.003
0.005
0.01
0.015
0.02
Adhesive thickness ( mm)

FIG. 4a

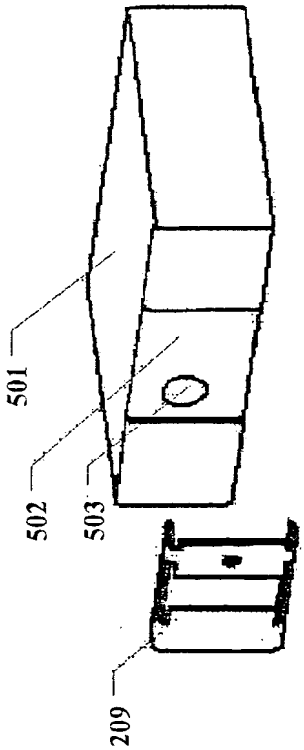


FIG. 5a

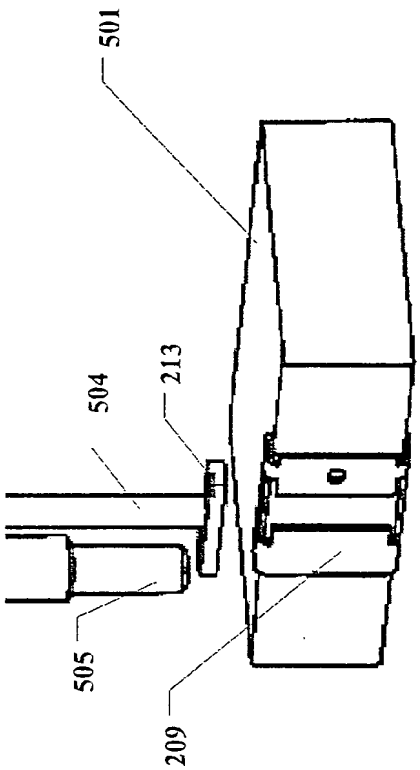


FIG. 5b

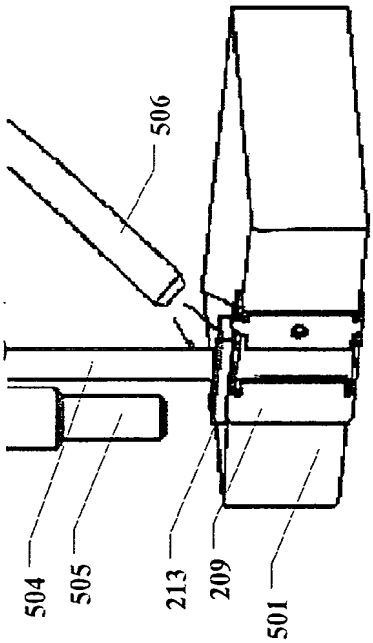


FIG. 5c

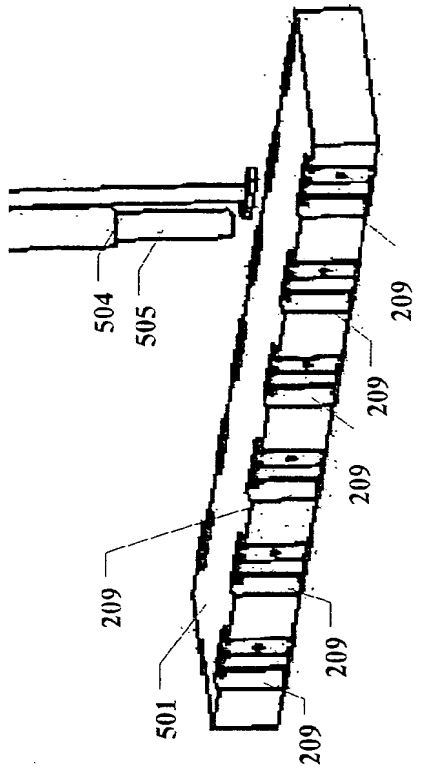


FIG. 5d

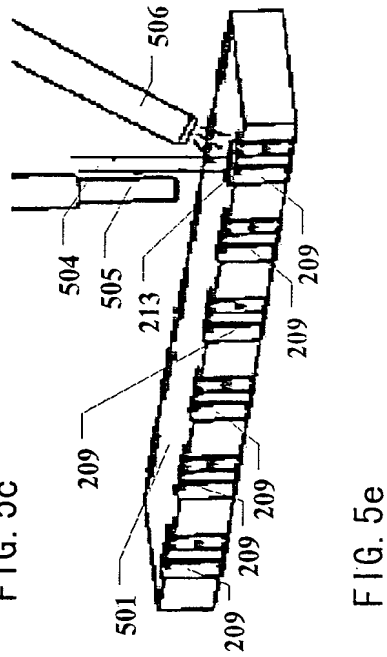


FIG. 5e

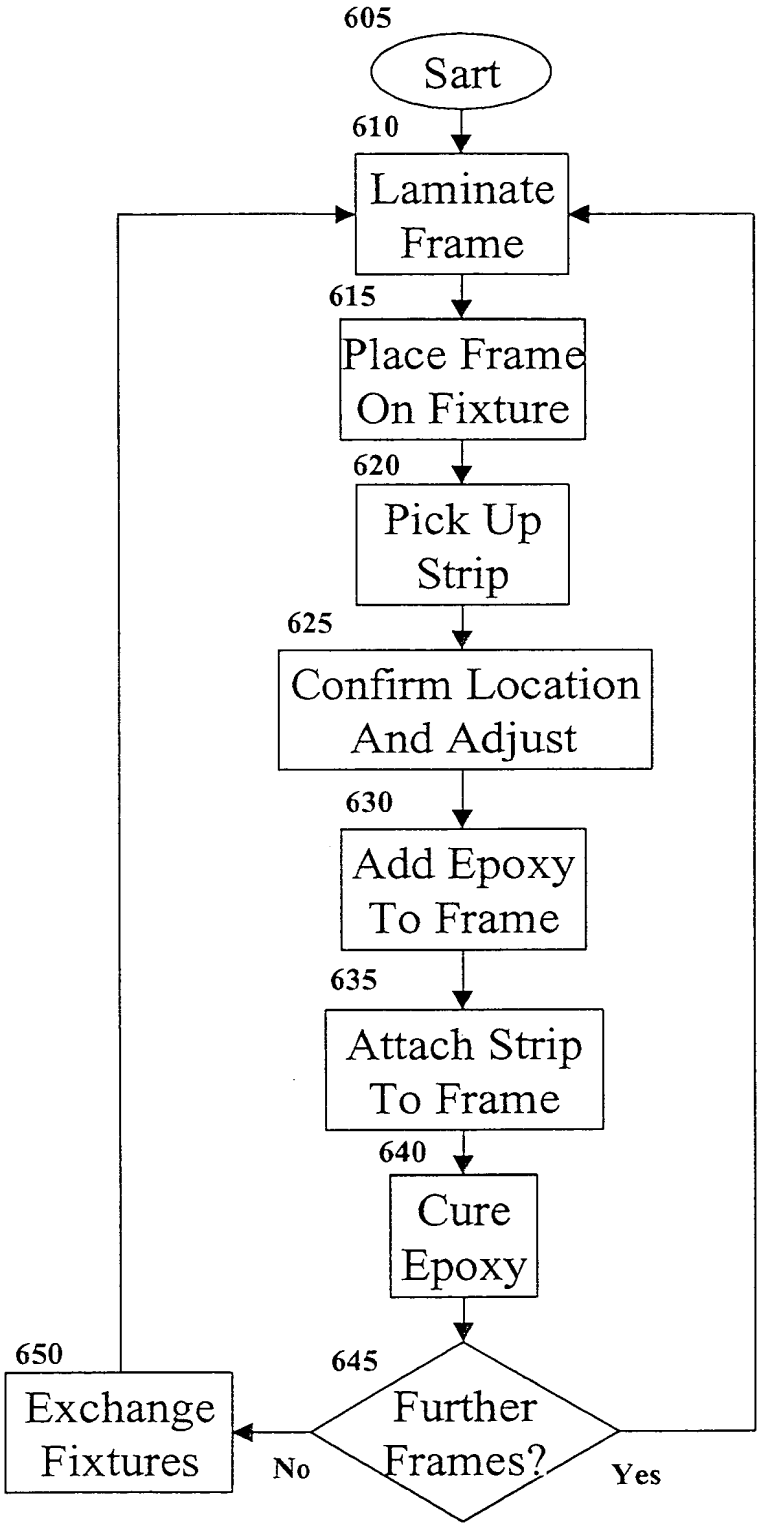
605
Sart
610
Laminate Frame
615
Place Frame On Fixture
620
Pick Up Strip
625
Confirm Location And Adjust
630
Add Epoxy To Frame
635
Attach Strip To Frame
640
Cure Epoxy
645
Further Frames?
No
Yes
650
Exchange Fixtures

FIG. 6

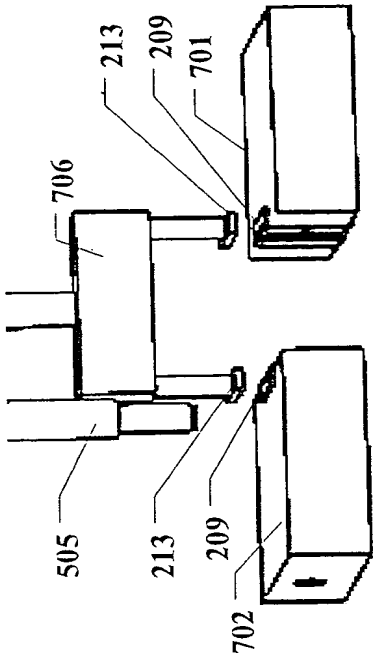


FIG. 7b

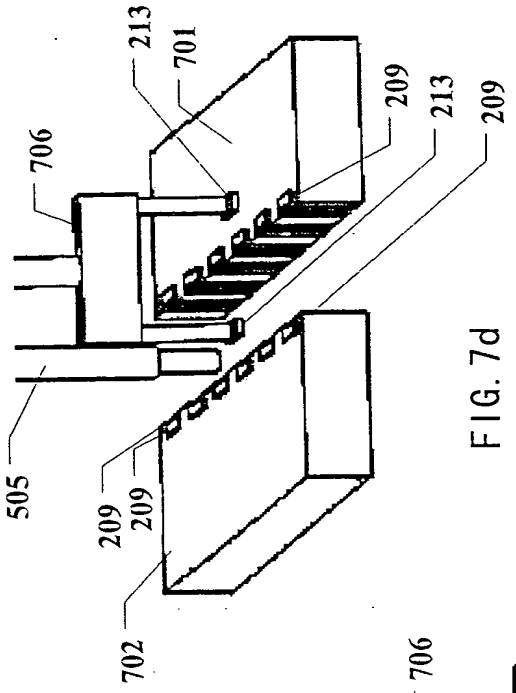


FIG. 7d

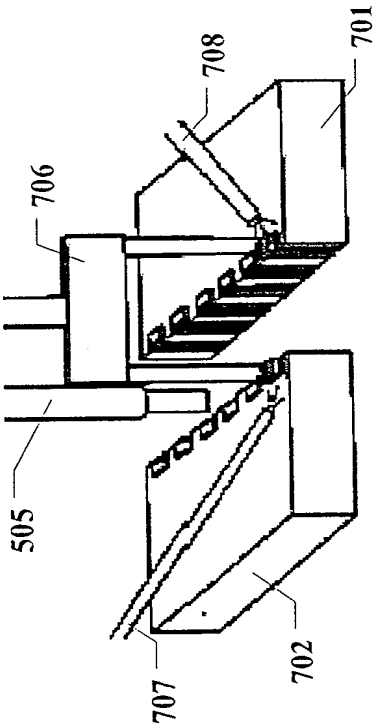


FIG. 7e

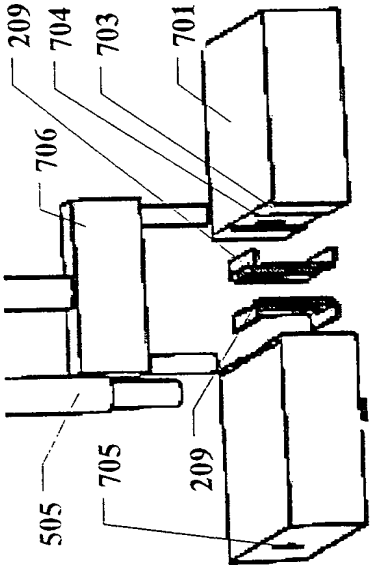


FIG. 7a

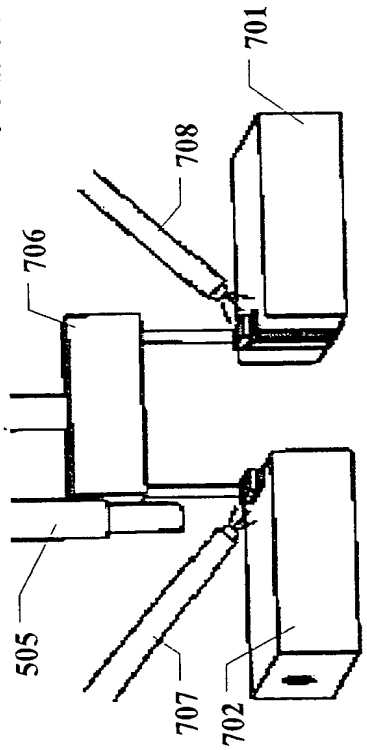


FIG. 7c

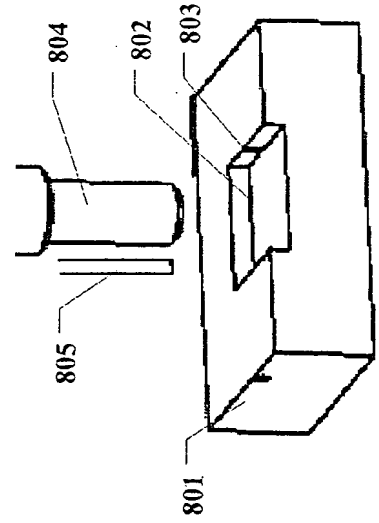


FIG. 8a

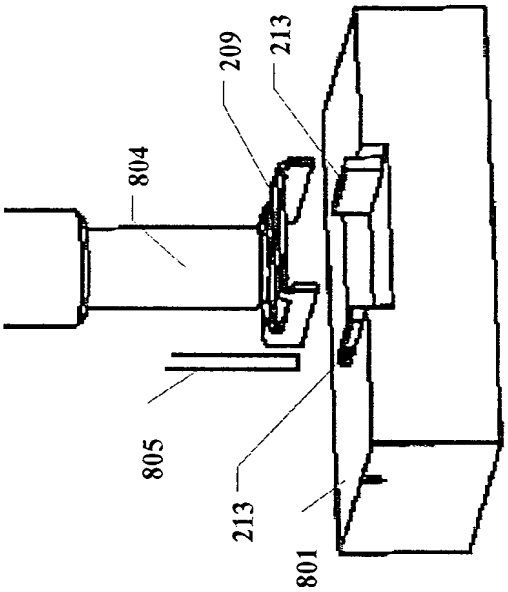


FIG. 8b

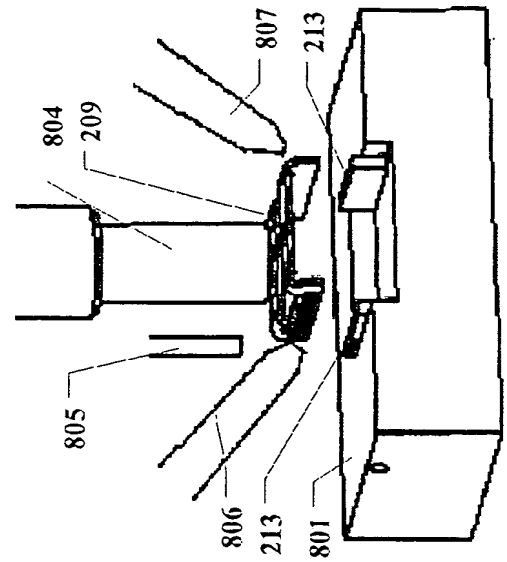


FIG. 8C




FIG. 8e

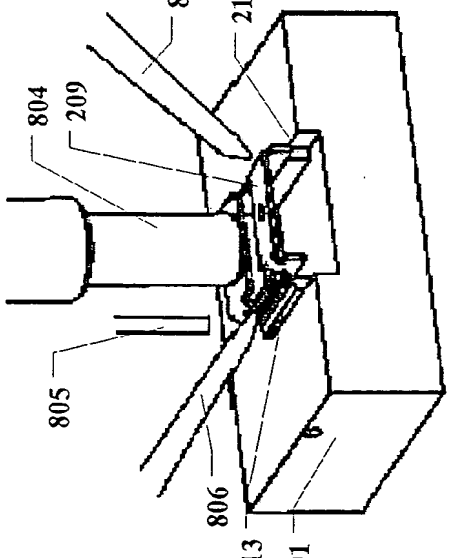


FIG. 8d

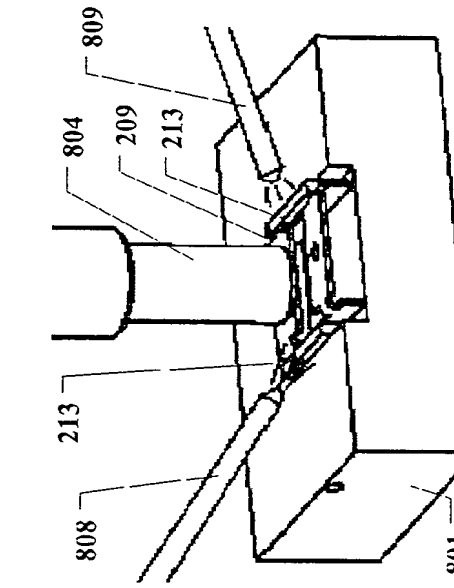


FIG. 8f

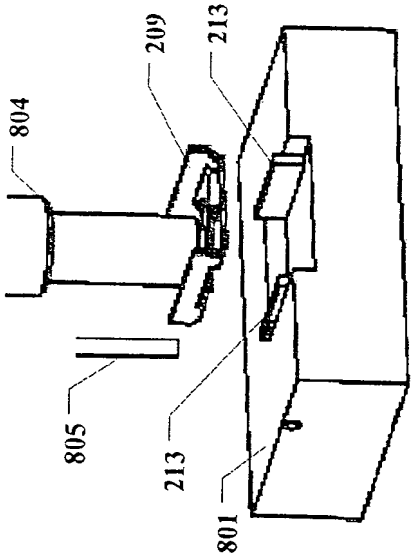


FIG. 9a

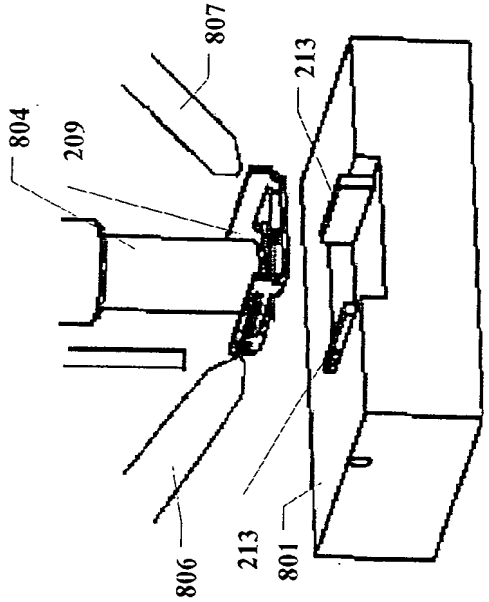


FIG. 9b

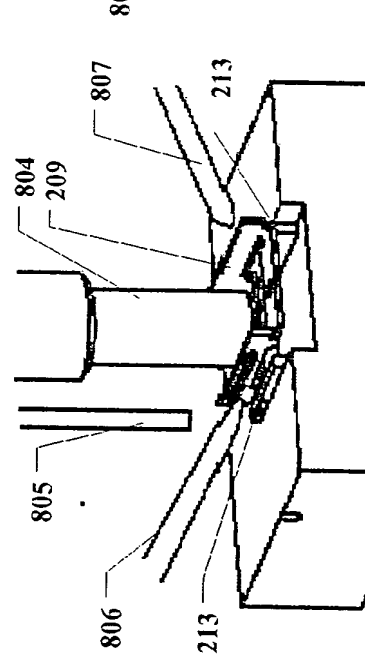


FIG. 9c

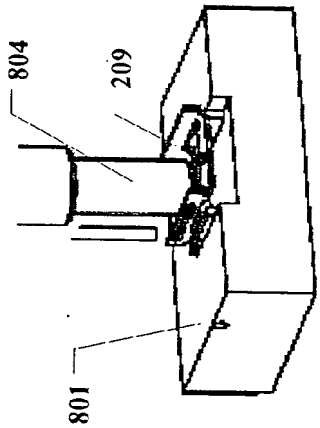


FIG. 9d

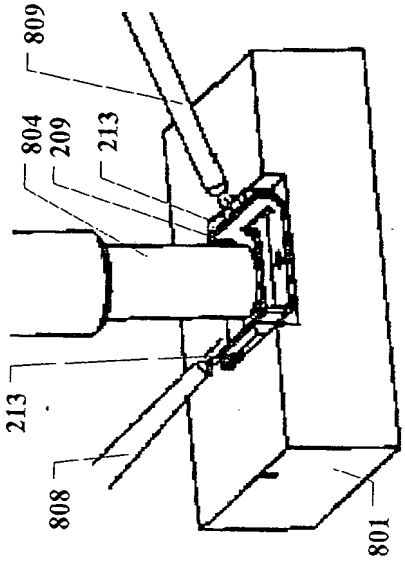


FIG. 9e